

Feed the Future Innovation Lab for Small-Scale Irrigation: Ghana

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Promising small-scale irrigation and fodder interventions in Ghana

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ACRONYMS

AfDB	-	African Development Bank
AgWMS	-	Agriculture Water Management Solutions
AWM	-	Agriculture Water Management
FAO	-	Food and Agriculture Organization (of the United Nations)
FASDEP	-	Food and Agriculture Sector Development Policy
GIDA	-	Ghana Irrigation Development Authority
GSS	-	Ghana Statistical Service
IFAD	-	International Fund for Agricultural Development
LACOSREP	-	Land Conservation and Smallholder Rehabilitation Project
METASIP	-	Medium Term Agriculture Sector Investment Plan
MOFA	-	Ministry of Food and Agriculture
NGOs	-	Non-governmental Organizations
NRGP	-	Northern Rural Growth Project
SSI	-	Small-scale Irrigation
UWADEP	-	Upper West Agricultural Development Project

1 SMALL-SCALE IRRIGATION IN GHANA'S AGRICULTURAL DEVELOPMENT

1.1 Relevance of Small-scale Irrigation

Agricultural production in Ghana and indeed the West African sub-region is still dependent on rainfall. However, the rainy season in the arid and semi-arid areas are very short and rainfall erratic. In the three regions of northern Ghana (Northern, Upper East and Upper West), rainfall is between April/May to September/October. The total quantity of rainfall in the northern regions continues to be between 900mm to over 1000mm, but erratic distribution and delays in the rainy season poses challenges. Sometimes droughts and floods occur in the same year; the rainy season only begins in late May or even June parts of the Upper East Region. In addition, the seasonal distribution of rainfall does not always match the seasonal water requirements of crops (and animals). Droughts and other types of unseasonable weather pose risks for rainfed dependent farmers (Namara et. al., 2011). Irrigation provides a good solution, because it can ensure water availability meets the water requirements of crops and animals.

While poverty has declined generally in Ghana, poverty in the northern part of the country has decreased only marginally or in some cases increased compared to other regions, as shown in Table 1. The lack of change in poverty rates in the northern regions is not unconnected with rainfall patterns and reliance on rainfed agricultural practices by small farmers in those regions. It is worth noting that Government of Ghana and development partners have acknowledged this disparity in development levels and increased efforts in agricultural development above the 8th parallel; Feed the Future's focus is primarily above the 8th parallel.

Table 1: Comparative Analysis of Poverty Incidence in Northern Ghana 1991-2006

Administrative Region	1991/92		1998/99		2005/06	
	% poverty incidence	% extreme poverty incidence	% poverty incidence	% extreme poverty incidence	% poverty incidence	% extreme poverty incidence
All Regions (Ghana)	51.7	36.5	39.5	28.8	28.5	18.2
Northern Region	63.4	54.1	69.2	57.4	52.3	38.7
Upper East	66.9	53.5	88.2	79.6	70.4	60.1
Upper West	88.4	74.3	83.9	68.3	87.9	79.0
Brong Ahafo	65.0	45.9	35.8	18.8	29.5	14.9
Volta	57.0	42.1	37.7	20.4	31.4	15.2
Central	44.3	24.1	48.4	31.5	19.9	9.7
Greater Accra	25.8	13.4	5.2	2.4	11.8	6.2

Note: Poverty line: ₵3,708,900/G₵371 per adult equivalent per year

Extreme poverty line: ₵2,884,700/G₵289 per adult equivalent per year

Source: Ghana Statistical Services, April 2007.

Irrigated agriculture is an important means to overcome the limitations of rainfed farming. According to Zhinong (2011) irrigation has permanently changed the social fabric of many regions around the world; it has provided major economic development semiarid and arid

areas, stabilizing rural communities, increasing income, and providing new opportunities for economic advancement. In particular to Ghana, well-targeted interventions in water have significant potential to contribute to rapid improvements in livelihoods of rural people (Santini, 2010). Indeed, the need to overcome limitations of rainfed agricultural production in the arid and semi-arid areas of the country through irrigated agriculture is widely acknowledged. The potential for this is high. According to an IFPRI study, Ghana has sufficient water resources for irrigation-based intensification; Ghana's irrigation potential ranges widely according to a variety sources from 0.36 to 1.9 million hectares (FAO 2005; Agodzo and Bobobee 1994 as cited by Namara et. al. 2011).

Farmers have been cultivating dry season vegetables on very small acreages using dug-outs¹ and shallow wells², as well as along the banks of rivers and streams. Notably, a recent census of 12,620 farm households found that the majority of farmers surveyed use some kind of water lifting device for dry season irrigation (Namara, 2014). The same study identified the bucket as the most common water lifting device, and petrol/diesel pumps the second most used method³. In addition, small dams mostly constructed during the colonial era for animal watering have been redesigned to be sources for irrigation, especially in the Upper East Region. Larger multi-purpose dams, such as those at Tono and Veia in the Upper East Region and Bontanga in the Northern Region, have been constructed by the government for irrigation and other purposes. A new large multi-purpose dam is being planned for the Pwalugu area of the Talensi District, Upper East Region.

Despite such efforts, irrigation in Ghana remains largely insignificant relative to potential. It is estimated that less than two percent of the total cultivatable area in Ghana is irrigated; total withdrawal as a percentage of total renewable water resources is 1.8 percent with only 66.4 per cent of that total withdrawn for irrigation (Namara et. al. 2011).

The lack of irrigation development has been partly because of the failure of “modern” irrigation systems in Ghana, as with much of West Africa. Numerous studies suggest that irrigated agriculture (using modern constructed dams) in Africa and especially West Africa has been a failure to a large degree (Dittoh, 1991a; Sarris and Ham, 1991; Musa, 1992; Mariko et. al. 2001). Indeed the World Bank had to suspend funding of irrigation projects in the late 1980s because of poor performance and very high costs in dam construction and maintenance (Sarris and Ham, 1991). The performance of irrigated agriculture using medium and large dams continues to be very dismal. In Ghana none of the medium and large dams can claim any significant success. In any case research indicates that formal irrigation systems (surface water gravity systems) tend not to favour small, poor farmers (Pant, 1992).

¹ Average farm size for riverine dug-out is 0.2 ha. (Spate Irrigation Network, 2014)

² Average plot size for temporary hand dug well is 500 ² m. (Spate Irrigation Network, 2014)

³ Average farm size using pumps to abstract from rivers is 0.4 – 6.0 ha. (Spate Irrigation Network, 2014)

In contrast to the dissatisfaction with formal (modern) irrigated production, informal (traditional) irrigated production appears to be performing relatively better. Indeed the area under informal irrigation in Ghana has been estimated to be about five times that under formal irrigation (Dittoh et. al. 2013). Others believe it is much higher (Nanes, 2012). At the final dialogue workshop of the AgWM Solutions in Accra, panel discussion members concluded that 80 to 90% of irrigation in Ghana is by smallholders (Dittoh and Akuriba, 2012). A press release by the AgWater Management Solutions Project at the Stockholm Water Week in 2012 said that, “in Ghana, small private irrigation schemes already employ 45 times more individuals and cover 25 times more land than public irrigation schemes”. As a result, there is now greater attention being paid to the potential to develop small-scale irrigation systems.

Yet, there is evidence of only a few attempts to develop this informal irrigation sector. The IFAD-funded Land Conservation and Smallholder Rehabilitation Project (LACOSREP) in the Upper East Region focused on the rehabilitation of small dams. Another example is the provision of motorized pumps by the Ministry of Food and Agriculture (MOFA) to a limited number of farmers. In terms of research, the Bill and Melinda Gates Foundation funded the Agriculture Water Management (AgWM) Solutions Project aimed at identifying how to support and build upon small farmer led initiatives. According to Nyamadi, the (2012) “AgWater Solutions has identified where investments can be targeted for maximum impact at the country, state and local levels”. There is need for much greater effort to improve what small farmers (irrigators) are already doing well.

1.2 Small-Scale Irrigation in Ghana’s Irrigation Policy and Development Plan

At national level, the Ghana Shared Growth and Development Agenda (2010-2013) proposed the development of appropriate irrigation schemes for smallholders. This was a continuation of earlier national and sector policies, as well as political manifestos. The Food and Agriculture Sector Development Policy (FASDEP II) (MOFA, 2007) is Ghana’s overall agricultural policy, and the Medium-Term Agricultural Sector Investment Plan (METASIP) 2011-2015 (MOFA, 2010) is Ghana’s agricultural development plan derived from the policy. Both documents allude to the importance of irrigated agriculture and highlight the potential for development. FASDEP II notes that “in 2002, the total area under formal irrigation was around 11,000 hectares whereas the potential area – including inland valleys – that could be developed for irrigation is estimated at 500,000 ha. The Ghana Irrigation Development Authority (GIDA) in 2000 identified 32,000 hectares of under-developed inland valleys throughout the country that could benefit from moisture improvement technologies for food production” (pp. 4-5). FASDEP II also recognizes some of the issues that constrain smallholder irrigation development, as “formal irrigation development has been very much supply-driven, and over-reliance on the formal system is limiting the area under irrigation” and “the informal sector (SSI) is not serviced sufficiently to realize its potential” (p.12). Despite these statements, the policy provides no guideline to operationalize small-scale irrigation development.

The METASIP further states the value of small-scale irrigation, noting that “emphasis should now be placed on micro and small-scale irrigation systems in the short- and medium-term since most of these have been largely successful”, though it recognizes the necessity “to also plan in the long term to develop large scale irrigation systems in large irrigable areas such as the Afram Plains, several valleys in the northern and southern savannas and the Accra Plains” (23). The METASIP proposes very ambitious SSI systems, for example “22,590 Ha of micro irrigation schemes by 2015 to benefit 50,000 households” (29) and “62,000 Ha of sustainable water harvesting and agricultural water management schemes in Northern and Southern Savannah zones” (30).

The Ghana National Irrigation Policy, Strategies and Regulatory Measures (MOFA/FAO, 2010) has a goal of “sustainable growth and enhanced performance of irrigation contributing full to the goal of the Ghanaian agriculture sector”. It addresses four key problem areas, namely:

1. Low agricultural productivity and slow rates of growth
2. Constrained socio-economic engagement with land and water resources
3. Environmental degradation associated with irrigated production
4. Lack of irrigation support services.

The policy clearly stresses the importance of irrigation in ensuring food security and poverty reduction. Indeed, it states that the major way of using water to reduce poverty is through the development of irrigation. It also identifies small, medium and large scale irrigation projects as well as public and private systems as all being important and necessary. The Ghana irrigation policy tries to ensure that all possibilities in different parts of the country are considered. The policy does not necessarily prioritize SSI over large-scale irrigation.

Finally, the National Water Policy has implications for the development of irrigation. The Water Resources Commission Act (No. 522 of 1996) Legislative Instrument (LI 1827- 2006) regulates drilling activities for groundwater resources in Ghana. The National Water Policy (June 2007) provides a framework for the development of Ghana’s water resources, including irrigation development. The National Water Policy clearly distinguishes between surface water and groundwater and notes that groundwater has a number of advantages over surface water. According to Policy document, the key objectives of the policy for irrigation are:

1. ensure availability of water in sufficient quantity and quality for cultivation of food crops, watering of livestock and sustainable freshwater fisheries to achieve sustainable food security for the country; and
2. ensure availability of water in sufficient quantity and quality to support the functions of the eco-systems in providing alternative livelihoods.

The measures outlined for the achievement of the objectives are:

1. support the establishment of micro-irrigation and valley bottom irrigation schemes among rural communities with the assistance of district assemblies;

2. strengthen district assemblies to assume a central role in supporting community operation and maintenance of small-scale irrigation and other food production facilities;
3. promote partnership between the public and the private sector in the provision of large commercial irrigation infrastructure taking into consideration effects on economy, culture, environment and health;
4. encourage the efficient use of fertilizers to reduce pollution of water bodies and ensure conservation of water;
5. promote and encourage water use efficiency techniques in agriculture and reduce transmission losses of water in irrigation systems; and
6. manage land use and control land degradation, including bush fires, to reduce soil loss and siltation of water bodies.

FASDEP, METASIP, the National Irrigation Policy and the National Water Policy all recognize the importance of irrigation, including SSI, for food and nutrition security, poverty reduction, increased employment, reduction in rural-urban migration, stability of rural communities etc. And, despite little indication as of 2014 that specific programs are achieving the ambitious goals, the Ministry of Food and Agriculture is reporting that the combined area cropped under both formal and informal irrigation in 2013 was 21,677.9 ha, an increase of 8.1% over 2012. This is primarily being achieved through small and private initiatives.

1.3 Public and Donor Programmes that Prioritize Irrigation

Ghana's policies on water and natural resource management are lauded for their progressiveness (Snyder et.al. 2013), but there is little evidence to show priority on irrigation at implementation stages. Government of Ghana funding for irrigation development has been very dismal, and low funding has been cited as a primary constraint to the development of public irrigation in the country. The main public institution responsible for irrigation development is the Ghana Irrigation Development Authority, a semi-autonomous authority that reports to the Ministry of Food and Agriculture. According to the current Chief Executive of GIDA, business models of bankable irrigation projects have been developed for the irrigation of 23,000 hectares, but funding has not been forthcoming (Nyamadi, 2012b). MOFA recently provided pumps at 33% of the market price to irrigators as a stop gap until other projects can be implemented."

There are 22 public irrigation schemes (see Table 2) at present; the number functioning is less than 22 and most in use are underperforming. Almost all the projects have been supply-led, rather than demand-driven, which research suggests leads to problems with sustainability and effectiveness, reflected in underutilization and lack of maintenance.

Table 2: Mode of Irrigation and Location of Public Irrigation Schemes in Ghana

Mode of Irrigation	Location of Irrigation Scheme
Run-off-river diversion and gravity-fed systems	Sata, Anum Valley
River pumping-based and gravity-fed systems	Aveyime, Kikam

Reservoir-based gravity-fed systems	Libga, Afife, Bontanga, Gollinga, Tono, Ve, Ashaiman, Kpong, Okyereko
Reservoir pumping-based gravity-fed systems	Dawhenya
Lake pumping-based sprinkler irrigation systems	Weija, Kpando-Trokor, Amate, Dedeso
River pumping-based sprinkler irrigation systems	Subinja, Tanoso, Akumadan
Reservoir pumping-based sprinkler irrigation systems	Mankessim

Source: Ghana Irrigation Development Authority (GIDA), 2012

In addition to public schemes, donor supported government and NGO projects and programmes have emphasized irrigated agriculture. The most prominent of them has been the IFAD-supported LACOSREP in the Upper East Region, which rehabilitated several small dams. IFAD also sponsored the Upper West Agricultural Development Project (UWADEP) which rehabilitated and built a few dams in the Upper West Region. The performance of rehabilitated and new small dams has still been below expectation due to several constraints (Birner et. al. 2010). Another IFAD and Africa Development Bank (AfDB) supported programme, the Northern Rural Growth Project (NRGP), has an elaborate irrigation plan, though not much has been implemented as yet. Several NGOs, including Care International, Plan International and the Catholic Diocesan Development Office in Bolgatanga have supported irrigation activities in the three northern regions.

2 RECENT RESEARCH ON SMALL-SCALE IRRIGATION IN GHANA AND THE WEST AFRICAN SUB-REGION

2.1 Findings of Agricultural Water Management Solutions Project in Ghana and Other Countries

The Agriculture Water Management Solutions project covered five countries in Africa; Burkina Faso and Ghana in West Africa, Ethiopia and Tanzania in East Africa and Zambia in Southern Africa as well as two states in India (<http://awm-solutions.iwmi.org/>). The goal of the AWM Solutions Project was “to help unlock the potential of smallholder farming by focusing on agricultural water management (AWM)”. That was to be done by “stimulating pro-poor, gender-equitable AWM investments, policy and implementation strategies through concrete, evidence-based knowledge and decision-making tools”. It was pointed out that to obtain concrete, evidence-based knowledge for the purpose of stimulating development, there was need to focus on the potential of varied groups of people in varied locations, the opportunities open to them and the constraints. Throughout the project, stakeholders’ views were paramount; most recommendations came from extensive dialogue with stakeholders at all levels.

The results concluded that “the three-year AgWater Management Solutions Research Initiative showed for the first time the scale at which enterprising smallholder farmers themselves are driving (an agriculture water management) revolution by using their own resources innovatively rather than waiting for water to be delivered”. The AWM Solutions

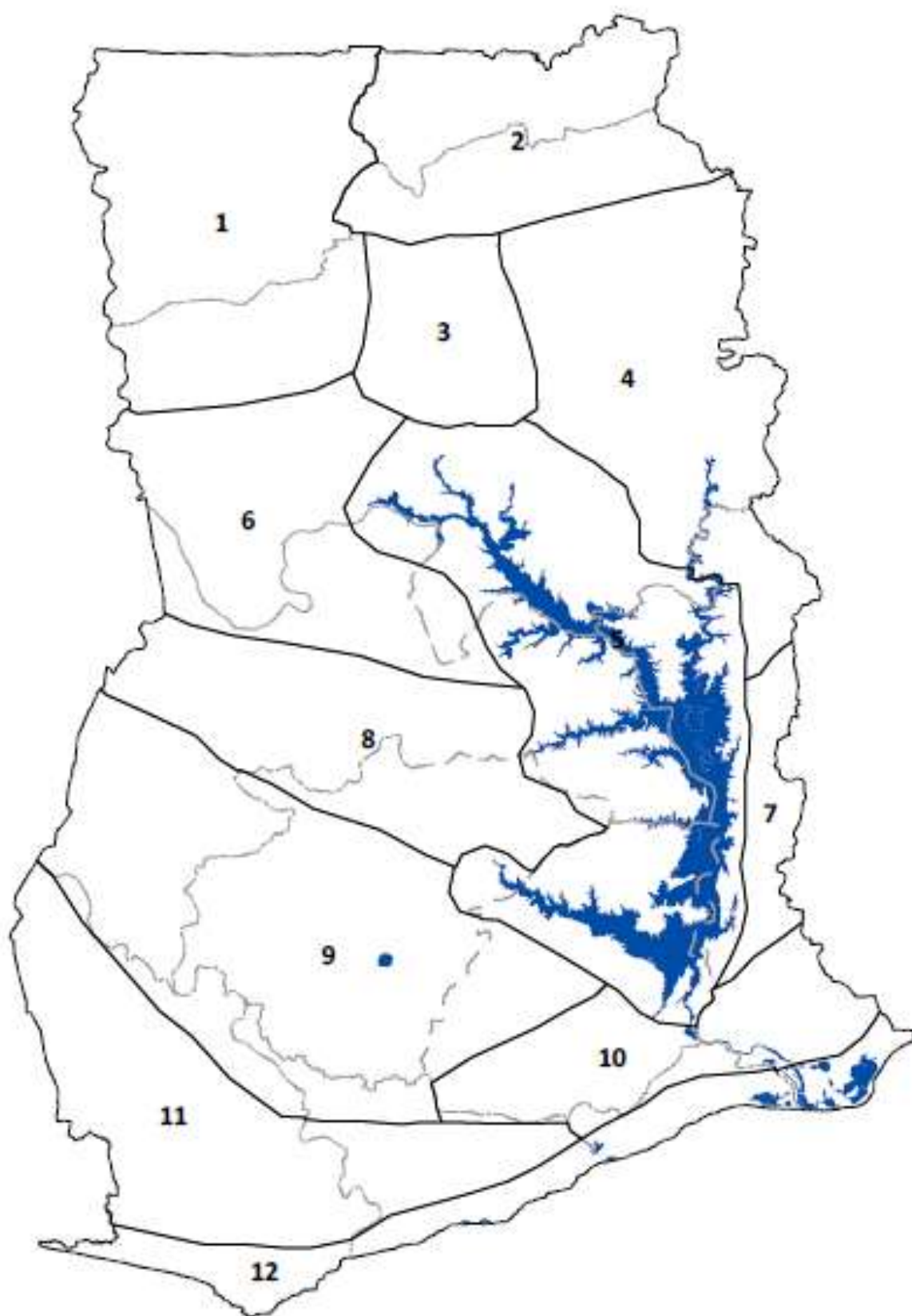
project emphasized what the people were doing and what improvements could be made upon those farmer-led initiatives to broaden the use.

In Ghana the project identified twelve livelihood zones, as given in Table 2 and Figure 1. The livelihood mapping analysis furthered understanding of existing and varied livelihood sources needed to develop appropriate programs that meet people's expectations. Livelihoods mapping enables identification of the type of water management technologies that fit the livelihood zones and areas with high AWM investment potential. Table 3 indicates agricultural activities prominent in the various zones and gives indication of investments that are likely to be acceptable, and thus likely to succeed in the various zones. It also indicates stakeholders' perceptions of water as a limiting factor in agricultural production in the various zones.

Table 3: Ghana Livelihoods Mapping and Stakeholders' Perceptions of Water as a limiting Factor for Agricultural Production in the Zones

Zone	Name of Livelihood Zone	Perception of water as a limiting factor for agricultural production
1	North-West Millet/Sorghum-Legumes-Cattle Livelihood Zone	High
2	North-East Millet/Sorghum/Rice-Legumes-Small Ruminants/Guinea Fowl Livelihood Zone	High
3	North-Central Maize/Rice-Mango-Groundnut-Small Ruminants Livelihood Zone	Moderate to low
4	North East Corridor and Upper Volta Yam/Cassava-Groundnut- Cattle Livelihood Zone	High
5	Volta Lake Inland Fishing Livelihood Zone	Moderate to low
6	Upper Middle Belt Maize-Yam/Cassava Livelihood Zone	Moderate
7	Middle Volta Cocoa/Coffee-Cassava-Small Ruminants Livelihood Zone	Moderate
8	Central Middle Belt Commercial Maize-Cassava-Small Ruminants Livelihood Zone	Moderate to low
9	Lower Middle Belt Cocoa/Oil Palm/Citrus-Commercial Poultry-Mining Livelihood Zone	Moderate
10	Inland Greater Accra and Lower Volta Commercial Rice-Cattle Livelihood Zone	Moderate
11	High Forest Timber-Cocoa/Oil palm/Rubber-Mining Livelihood Zone	Moderate to low
12	Coastal Belt Marine Fishing-Vegetables-Salt Livelihood Zone	High

Note that the Feed the Future geographical focus in Ghana is approximately Zones 1 to 6 in areas above the 8th parallel. The northern savannah and derived savannah ecological areas are where the Feed the Future target crops (maize, rice and soybean) are grown.



Ag Water Solutions identified the following as potential AWM solutions for Ghana. These solutions were arrived at through scoping studies and in-depth workshop discussions.

1. Shallow groundwater
2. Tube well (Borehole)
3. Private pump from rivers and streams
4. Communal pump
5. Large commercial pump from rivers
6. Out-growers
7. Private small dams/dugouts
8. Public private partnership (to include public surface reservoir systems)
9. Communal small dams/dugouts

For the purpose of this discussion paper, these solutions can be presented as in Table 4:

Table 4. Potential AWM solutions

Source	Storage	Conveyance	Institutional and/or ownership structure
Groundwater	Shallow and tube wells	Pumps (motor and hand/pedal)	Communal or private
Surface water (rivers, streams)		Pumps (motor and hand/pedal)	Private
Surface water (rivers)		Large pumps	Commercial
	Small dams/dugouts		Private or communal
	Surface reservoir systems		Public

Outgrower arrangements and public private partnerships were identified as the main potential solutions for institutional or organizational arrangements.

The Ag Water Solutions research also emphasized that each of the AWM solutions would best suit particular livelihood zones. Under that project, stakeholders identified through a workshop which AWM solutions were best for which particular livelihood zones using criteria of relevance, physical suitability, livelihood impacts, gender equitable benefits, level of upscalability, environmental impact and constraints. Table 5 gives a summary of the stakeholders' assessment. The results indicate that Zones 1, 2, 4 and 12 are very suitable for **all** the identified AWM solutions assessed, while Zones 5, 9 and 11 are not suitable for any of the solutions discussed under that project. The solutions highlighted in blue show those seen as high potential.

Table 5: Overall Assessment of Suitability of AWM Investments in the Various Livelihood Zones

AWM Solutions		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10	Zone 11	Zone 12
Ground-water irrigation	Motor pumps (private or communal)	***	***	*	***	*	**	**	*	*	*	*	***
	Manual pumps	***	***	*	***	*	**	**	*	*	*	*	***
	Bucket-Fetch	***	****	*	***	*	**	**	*	*	*	*	***
Surface water irrigation (rivers/ streams, dams, dugouts)	Gravity flow	***	***	***	***	*	**	**	***	*	**	*	***
	Motor pumps (private or communal)	***	***	***	***	*	**	**	***	*	**	*	***
	Manual pumps	***	***	***	***	*	**	**	**	*	**	*	***
	Bucket-Fetch	***	***	***	***	*	**	**	*	*	*	*	***

*** Very Suitable ** Suitable *Not suitable

The project finally recommended the solutions given in Table 6 for consideration for investment and promotion by stakeholders, while noting the constraints that needed to be overcome.

Table 6: Summary of AWM solutions, recommendations, potential beneficiaries and estimated cost.

AWM solution	Beneficiary households (% of rural households)*	Area (% of total agricultural land)*	Estimated investment costs (USD)
Inland valleys can be used to increase the extent of rice cultivation. Improving water management, agronomic and post-harvest practices will all be required for success.	261,000-377,000 (7-10%)	391,000-565,000 (2-3%)	USD600/ha
Motor pumps can increase yields and incomes but problems need to be overcome in areas like financing, cost reduction (e.g. electricity supply), distance to pumps suppliers, poor operation practices and maintenance.	564,000-730,000 (16-20%)	451,000-584,000 (2-3%)	USD400/household
Small reservoirs need better management at all stages to reduce costs and improve equity.	74,000-163,000 (2-4%)	74,000-163,000 (1%)	USD750,000/ m ³ of water stored
Outgrower schemes could provide a means to support smallholder farmers, including women, but they need facilitation, regulation and support.	Not calculated	Not calculated	Not calculated

Note: * Figures assume that out of the total potential beneficiary households calculated, 50% adopt the AWM option.

Source: Evans et. al. 2013; FAO, 2012

2.2 Other Research Findings on SSI in Ghana and the West African Sub-region

SSI in West Africa

Apart from the Ag Water Solutions project, other researches have established the important role SSI plays and can play in agricultural development in Ghana and West Africa, some of which has been noted above. It has also been found that across West Africa (Ghana, Burkina Faso, Niger, Mali and Senegal) there is general preference of farmers for small-scale irrigation systems, which are manageable with limited resources and low technological knowledge (Dittoh et. al. 2010). Both surface and groundwater are used for small-scale irrigation using a variety of storage options. Surface water is obtained from rivers, streams and small dams, in which rivers and streams may be perennial or seasonal according to the rainy season. In terms of conveyance technologies, in the Upper East Region, it has been established that the use of small pumps for irrigation “is far more beneficial than other irrigation methods” (Dittoh et. al. 2013b, p. 449).

Namara et. al. (2014) found that most farmers are aware of the potential of pumps and would prefer to use pumps, though most rely on buckets as the most affordable, low-risk option.

Small dams and reservoirs

The potential for small dams and reservoirs for water storage shows promise, particularly to capture surface run off for use in the dry season, according to recent studies. Small dams are relatively common in Ghana, particularly in the Northern, Upper East and Upper West regions. Over 500 small dams and dugouts are known to be in these regions (Namara et. al. 2011). Most of them are multipurpose dams used for livestock watering, irrigation, domestic use and fisheries. A recent study on the White Volta showed the both the prevalence and potential of small dugouts in flood plains of rivers and streams (Spate Irrigation Network, 2014). Though their performance has also not been excellent they have been rated better than medium and large scale dams (Dittoh, 1996).

Small reservoirs have been promoted as a means to enhance resiliency and reduce vulnerability. At the same time, these have also been criticized for high costs, poor results and lack of sustainability. A recent study that included Ghana acknowledged the various challenges with reservoirs, but also concluded that the shortcomings were not inherent to reservoirs as a technology, but rather the result of weak planning and implementation processes that led to flawed construction and inadequate designs as the result of the lack of attention to multiple uses of reservoirs, which in turn contributed to difficulties with operation and maintenance (Venot et. al. 2012). The same study also noted that while Water Users' Association mandated by donors had not been able to compensate for the flaws in the reservoir development process, enhanced institutional relationships at multiple levels could lead to more promising outcomes of the technology, including for smallholder farmers.

Groundwater

In general, there has been paucity of information of Africa's groundwater potential. While some have argued that Sub-Saharan Africa does not have large, high-yielding shallow aquifers like those found in Asia (Calow and MacDonanld, 2009), this is now being challenged. Recent research on groundwater points to substantial potential for expansion of groundwater (Obuobi et. al. 2013; Ayenew et. al., 2013). Another study indicates that groundwater irrigation is growing in both extent and importance in arid and semi-arid areas of Sub-Saharan Africa (Giordano, de Fraiture, Weight and van der Blik, 2012, Pavelic et. al. 2013).

Amid this debate, irrigation by shallow (temporary) and permanent wells using groundwater is widespread and highly regarded by farmers in Ghana as a whole, and in the northern regions in particular. Temporary wells tend to be found on lands rented during the dry season and are filled in prior to returning the land to the 'owner' during the regular rainy season. It is estimated that Ghana has more than 56,000 groundwater abstraction systems, comprising boreholes, handdug

wells and dugouts (Kortatsi 1994). Nanes (2011) has argued that in the Upper East Region of Ghana, more farmers irrigate with groundwater than surface water, and that the area irrigated with groundwater is higher than that of surface water.

In addition to the farmers, researchers and implementers also see the importance of prioritizing groundwater development for food production. Foster et. al. (2008) have noted that there is need for “urgent and substantial investments” in groundwater resources development and management because without effective use of available groundwater resources, reducing poverty and stimulating livelihoods in Sub-Saharan Africa will not be possible. Allaire (2009) has also stated that groundwater irrigation offers potential to mitigate the effects of drought and erratic rainfall on agricultural production because groundwater levels are less correlated with rainfall.

However, the sustainability of groundwater is debated. One study in Nabogo basin (a subcatchment of the White Volta river basin) showed that current well pumping rates yield significantly less water than annual groundwater recharge to the basin (Lutz et al. 2007), while a separate study found that groundwater use would be sustainable from a geo-scientific point of view given the current recharge and development rates (Nicola and Nick 2005). A less positive study by Gyau-Boakye and Tumbulto (2000) noted that increasing abstraction of groundwater has led to depletion of groundwater resources in some areas in Ghana. That could be so due to that regions heavy reliance on groundwater for domestic water-supply, rural livelihood and livestock rearing and irrigation. As others have cautioned, groundwater development has to be carefully managed because over-exploitation of groundwater can easily take place (MacDonald et. al., 2009) and cause more serious livelihood problems.

Though the research is mixed, some evidence supports the view that small farmers are doing the right thing by expanding groundwater irrigated production. In Ghana, SSI with groundwater has been privately driven. Government, NGOs and development partners have not invested in groundwater relative to irrigation with surface water, such as the dams and reservoirs filled by rivers and streams (Nyamadi, 2011b).

2.3 Challenges in developing SSI

While some research has been done on potential for various irrigation technologies and approaches, studies have also pointed out the challenges that have constrained further development.

An IFPRI study noted that the “economics of irrigation in Ghana are questionable” (Namara, 2011). The low profitability of food production is often noted by farmers as the main constraint to private investment in irrigation. Irrigated farming tends to be limited to vegetable and rice production, because those are the only crops that appear to be profitable given the high costs of irrigation development and operation. Cereal crops, which farmers need to diversify risk and ensure household food security, are not irrigated because the high cost of irrigation makes it unprofitable; this lack of irrigation constrains staple food crop production (Al Hassan and Poulton, 2009). Namara et al. (2011) identified the following factors that influence profitability:

- water control offered by the system, which influences yields;
- costs of irrigation;
- crops grown (which could be a function of access to markets); and
- use of complementary inputs.

The same IFPRI study notes the various reasons for higher than average costs of irrigation development, which includes no less than 12 factors, not including those additional factors that contribute to high cost of groundwater irrigation development (Namara, 2011). An above mentioned study on reservoirs noted the high costs of reservoir development, mostly associated with flawed procurement processes (Venot et. al., 2012).

While those studies focused on high costs of formal or public irrigation system development, the majority of irrigation is SSI and privately developed. The costs of private scheme development are generally lower than on public schemes. In those cases, the high costs of water lifting also become particularly important. Namara et. al. (2014) focused on issues related to the adoption of water lifting method, and found that constraints related to: limited access to equipment, high operational and maintenance costs, lack of access to finance, output market risks, and inadequate government support and extension services. They also found that farmers maintain buckets even when using pumps to protect against risk.

The above discussion has focused on the high cost of irrigation development, investment and operation, and issues related to profitability, but Namara (2011) summed up the overall constraints to irrigation development as the following:

1. financial and institutional issues;
2. access to inputs and services;
3. output marketing and post-harvest handling or value additions;
4. technical constraints;
5. biophysical constraints;
6. labor availability; and
7. land availability.

3 LIVESTOCK AND FODDER PRODUCTION IN GHANA

3.1 Livestock in Ghana's Agriculture Policy and Development Plan

Livestock does not seem to be very prominent in Ghana's agriculture. Apart from a few organized commercial poultry and pig farmers, the livestock sub-sector consists of small-scale operators who are primarily crop farmers that also keep livestock to supplement their incomes. That does not however imply that livestock does not play important roles in the livelihood strategies of the people. It is important for food and cash security especially in the rural areas of northern Ghana. "Diversification into livestock production by crop farmers is a key strategy to reduce risk associated with rain-fed agriculture" (Amankwah 2013). That said most of the

animal protein needs of Ghanaians are obtained from fish. While only about 102,000 metric tons of meat was produced in 2008, fish production was about 431,000 metric tons (MOFA, 2010).

The development of the livestock sub-sector is definitely important and Ghana's agricultural policy (FASDEP II) and the METASIP recognize that. FADEP II notes that livestock breeds are of low productive capacity and there are no interventions that effectively address problems of lack of feed and water, particularly in the dry season. This problem of inadequate availability of quality feed has been identified in the livestock development policy as an important issue confronting the livestock sector and that there is need to "improve access to quality feed and water" (MOFA, 2007 p. 37). The goals of livestock policy are to "increase the supply of meat, animal and dairy products from domestic production at the current aggregate level of 30% to 80% by the year 2015; and contribute to the reduction of the incidence of poverty among farmers (who are also livestock keepers) from 59% to 30% by the year 2015" (ibid).

The METASIP proposes the following with regards to livestock nutrition:

1. Promote communal grazing lands
2. Facilitate and support establishment of pastures and fodder crops by farmers
3. Facilitate and support improvements in livestock housing by farmers

The proposal is to help enable "income from livestock rearing by men and women increase by 10% and 25% respectively by 2015" (p.33). It is doubtful if any of these proposals has started. Donor funded livestock development programmes have been implemented in the past and there is an on-going African Development Bank supported Livestock Development Project. These have however not been visible and past projects and programmes have proved to be unsustainable; it is difficult to trace the benefits now.

The poultry industry has been in distress for decades due to numerous problems, including high production cost, lack of feed and unrestricted 'dumping' of frozen chicken into the Ghanaian market, despite being the main commercial livestock industry in Ghana (USAID, 2013).

3.2 Irrigated Fodder Production in Ghana: Current Status and Opportunities for Investment

Background and current status

Ghana Irrigation Development Policy was approved on June 30th 2010 to address the problems, constraints and opportunities across the whole irrigation sub-sector. The policy is meant for informal, formal and commercial irrigation. The target of the policy is to put an area of 500,000 ha under irrigation in the medium term. There has been more than twenty irrigation schemes/projects implemented in Ghana since 1970s with the main focus on crops such as rice, maize, cowpea, and vegetables such as tomato, okra, pepper, and onion. Irrigation is easily

associated with rice, maize and vegetable production and not forage or pasture production. However, residues from irrigated cowpea production are used for livestock feeding and often in high demand for peri-urban small ruminant (sheep and goat) fattening. Research and development work on irrigated forage production in Ghana is virtually absent even though the necessary facilities (dams, rivers, fodder species, etc.) exist throughout the country.

The absence of investment in irrigated fodder production could partly be attributed to extensive and semi-intensive livestock production systems in Ghana with associated multiple production objectives, which essentially depend on natural pastures and crop residues from rain-fed crop farming. There have been research efforts in the past to improve the natural pastures under rain-fed conditions. Some of the forages largely tested at research stations often on small plots are presented in Table 6 below. Fodder banks were established in Northern Ghana in the 1980s and 1990s using some of the forage grass and legume species listed in Table 6. Trials in the 1980s and 1990s at the agricultural research stations, state owned ranches and few smallholder farmers with sown pastures using indigenous and exotic species of grasses and legumes were implement with no major success story.

Table 6: Forages Tested and Adapted to Farming Systems in Ghana

	Grasses	Legumes	Trees/Browses
1	<i>Panicum maximum</i>	<i>Stylosanthes hamate</i>	<i>Leuceana leucocephala</i>
2	<i>Brachiara ruziziensis</i>	<i>Centrosema pubescens</i>	<i>Sesbania grandiflora</i>
3	<i>Cenchrus ciliaris</i>	<i>Macroptilium atropurpureum</i>	<i>Gliricidia sepium</i>
4	<i>Chloris gayana</i>	<i>Macroptilium lathyroides</i>	<i>Pterocarpus evinacelus</i>
5	<i>Cynodon nlemfuensis</i>	<i>Desmodium intortum</i>	<i>Afzelia sp</i>
6	<i>Andropogon gayanus</i>	<i>Mucuna pruriens</i>	<i>Ficus sp</i>
7	<i>Tripsacum luxum</i>	<i>Cajanus cajan</i>	
8	<i>Setaria sphacelata</i>	<i>Flemingia macrophylla</i>	
9	<i>Vetiveria fulvibarbis</i>	<i>Lablab purpureus</i>	
10	<i>Ctenium newtonii</i>		
11	<i>Brachiaria falcifera</i>		

Source: CSIR-Animal Research Institute, Accra

CSIR-Animal Research Institute maintains a display of these forages at the Pokuase station.

Lessons from past attempts on rain-fed fodder production

1. Most of these attempts were project-driven with little engagement with local populations in the design, implementation and evaluation of the activities. Hence, most of these activities were not sustained beyond the lifespan of the project.
2. Some of these projects were located in remote areas that were difficult to access and were not well linked to the market. Government interference influenced the locations of some of these projects.
3. Most of the past attempts on fodder production were largely on-station research with little or no consideration for translating research results into development outcomes (CSIR-ARI, 2012).
4. There is an absence of medium- and long-term plans for forage seed production. Forage seed production was made even more difficult with low germination rates of some of the forage species. The limited availability of locally produced forage seeds further hindered scaling up and out of promising forage species.

Opportunities for irrigated fodder production

The potential exists for irrigated fodder production for the following reasons:

1. Increased demand for livestock products and the related growth of domestic investment (wealthier Ghanaians and government officials) in livestock enterprises, which are often integrated with crop farming and horticulture that are under irrigation.
2. Growing demand for feed for the increasing number of livestock in peri-urban areas of Ghana, where livestock was not historically common and that is less suitable to grazing. The general flow of cattle, sheep and goats in Ghana has tended to be from the three major livestock producing regions of Upper West, Upper East and Northern, as well as the Volta Region to the urban centers in the southern part of the country, but commercial cattle farming with absentee ownership by professionals and businessmen is on the rise in the Coastal Savannah zone of the country with varying levels of management (Oppong-Anane, 2001). Zero grazing options are increasingly required; suitable forages for intensive production that are amenable to zero grazing include *Stylosanthes hamata*, *Panicum maximum* and *Cenchrus ciliaris*.
3. Demand for reduced cost feed and fodder production for commercialization of livestock production in the peri-urban areas and related increase in demand for forage seeds among both existing and emerging commercial farmers (ibid.).
4. Availability of necessary facilities such as dams, rivers and small reservoirs for irrigation and the possibility of combining irrigated fodder production with vegetable production, particularly in the late dry season when feed scarcity is acute.
5. Rehabilitation of lands that have been subjected to surface mining could provide an opportunity for fodder production (ibid.).

4 SYNTHESSES OF RESEARCH FINDINGS AND LESSONS FOR GHANA'S IRRIGATION ASPIRATIONS

The research evidence clearly points to the resilience of small-scale agricultural systems, which continue to adapt and survive even where 'modern' agricultural systems introduced in varied ecological zones have not been sustained. This also applies to irrigation and water management in Ghana. While almost all the formal (modern) irrigations systems are facing problems, farmer-driven SSI systems continue to expand regardless of the lack of or inadequate support from government, NGOs, donors and research institutions. SSI has the potential to move from lower profitability to more profitable levels and reduce poverty significantly with appropriate assistance. It is equally important to state that an effective approach to such support is not standard technology transfer, but rather effective integration of modern and traditional (local) technologies through participatory technology development processes. Dittoh (1991b) suggested the adoption of an Informal/Formal Irrigation Integration Model, and recent evidence suggests that may be an effective approach with modifications to the local context.

An important lesson from the AgWM Solutions research, in particular, is the importance of the development of trust and common understandings of development issues to partner effectively with stakeholders. Project recommendations often came out of stakeholder views and recommendations, which were critically debated and validated. The failure of pasture and fodder development research efforts in northern Ghana in the 1980s and 1990s can be attributed to lack of collaboration and dialogue with local stakeholders. Other recent research similarly pointed to and developed training materials for enhancing participatory approaches in SSI development. (Snyder et. al., 2013).

Research also points to key constraints in further development of SSI, whether through public or private investment. A key challenge is profitability; high costs of irrigation hinder profitability and limit expansion of irrigation. Research shows that the primary crops grown by irrigators are vegetables, including tomatoes, onions, peppers, leafy vegetables and others, primarily because those are the only high value crops that are profitable under the existing high costs of irrigation. In order to achieve increased productivity in staples and cereals through irrigation, investment costs must come down. High costs of irrigation also contribute to inequitable agricultural development as only the wealthiest farmers are able to invest in irrigation and increase their production through intensification. As such, the high cost of irrigation development (and corresponding low profitability) is one of the primary challenges to expansion of irrigation and increasing productivity of not only high value but staple crops and fodder.

Many research projects have also pointed to the lack of data in Ghana that is required not only for analysis but also for proper planning and project implementation. There is an urgent need to

bring existing data together, assess gaps in data and systematically use the data for both farm scale and large scale analysis in planning.

The successful but limited irrigated production by small farmers using shallow wells, small dams and motorized pumps indicates the great potential of SSI for food and nutrition security, increased incomes and employment, including throughout the long dry season. Ghana's irrigation aspiration is to comprehensively develop irrigated agriculture in an inclusive manner that emphasizes SSI because of the advantages for household food and nutrition security, poverty reduction and increased employment in the poorer parts of the country. Additional research with the support of Feed the Future can support achievement of these national goals.

5 IDENTIFICATION OF RESEARCH GAPS ON SMALL-SCALE IRRIGATION IN GHANA

The discussion so far indicates some research gaps that require further discussion and interventions, including the following:

1. The real potential of the promising solutions identified by the Ag Water Solutions need to be determined through farmers-researcher in-field collaboration. Constraints at farm and other levels in the irrigation value chain cannot be easily identified until potential solutions are tried and refined.
2. Irrigation value chain research is needed to further analyse the high costs and profitability issues of irrigation. This then enables analysis of the potential of various SSI technologies for different crops, including staples, and fodder.
3. Drip irrigation, which is largely a SSI system, has been argued to be most suitable for small farmers especially in arid and semi-arid areas (Pasternak et al., 2006). However, the evidence on the potential for drip irrigation in much of sub-Saharan Africa is not positive. There is need to further test the feasibility of drip irrigation in comparison to other options (e.g. sprinklers) in the northern regions of Ghana.
4. Crop-livestock integration by irrigation households is a model also worth testing, particularly as Ghana's livestock population appears to be increasing and access to fish for protein is decreasing. Various models for integrating fodder into irrigated areas need to be considered.
5. Institutional constraints also form part of the critical challenges to successful development of irrigated agriculture. The lack of irrigation extension personnel and

the general extension service's lack of irrigation expertise are examples. Irrigation curriculum needs to be developed, piloted and implemented in training required personnel.

6 Next steps for the Innovation Lab for Small-scale Irrigation in Ghana

1. Identify the demands and needs for research interventions in SSI through engagement and consultation with stakeholders, including a review of the Ag Water Solutions research results and recommendations, and individual meetings with potential partners and stakeholders.
2. Develop criteria for interventions and demonstration sites based on initial consultation, priori research and ILSSI's strengths and mandate. The criteria will enable assessment of interventions that fall within the scope of ILSSI.
3. Finalize the research interventions and potential sites of field demonstrations through roundtable consultations with key ministry officials, GIDA, research institutes and universities. This will consider and build on synergies with Feed the Future and Africa Rising and Government of Ghana programs and projects.
4. Identify capacity development activities needed to develop and carry out the research, and strengthen capacity for sustaining research and analysis following project closure.
5. Identify the data sources for modelling various interventions; assemble existing data and identify data gaps to be filled by ILSSI and others; and support the input of data into models (Integrated Decision Support System).

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